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HAZARDS IN CONNECTION WITH CONCENTRATED COAL MINING[1]

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Records indicate that to date fewer than 200 of our approximately 7,500 coal mines (less than 3 per cent) are using the newer or concentrated mechanical mining systems, and of these operations it is improbable that as many as 50 produce full tonnage from the newer systems; in many mines listed as using the newer or concentrated methods, more than 75 per cent of the output comes from the older parts of the mine where the old methods are employed. In 1925 the total coal tonnage from the newer methods for the United States is given as a trifle over 6,000,000, or a little over 1 per cent of the tonnage of the United States, and it is probable that 1927 tonnage from these methods was under 10,000,000. Hence it is seen that the concentrated mechanical methods are in their infancy, and it seems that this should be an opportune time to point out some of the pitfalls to safety that are likely to be encountered, with the idea of helping to prevent accidents or disasters and not in any degree with intent to prevent the spread of the mechanization of mines or concentration of mine workers or mine workings.

In the introduction of concentrated systems of mining largely dependent upon the assumption of much of the burden of underground work by mechanical contrivances, with consequent concentration of work and of the working force, in general but little attention has been paid the element of safety. Discussions of mechanical drilling, cutting, loading, conveying, hauling, etc., have ordinarily been characterized by an assumption (which is inferred rather than uttered) that safety will be enhanced rather than in any manner retarded or lessened by concentrated mining methods and devices. There have been a few attempts to show that mechanical mining is safer than are the more primitive ways of doing underground work by man power; a few figures or brief statistical records have been advanced tending to indicate that the concentrated systems using mechanical devices have actually shown fewer accidents per 100,000 tons of coal produced than has been the case in the same mines or mining regions when the older hand methods were utilized.

There have been, however, a number of places where the concentrated systems have had to be abandoned, chiefly on account of the safety element; and there is much probability that some of these systems which in themselves are or can be made to be reasonably safe will fall into disrepute because of failure of those in charge to use reasonable care to keep the work and workers safe. In fact one State

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inspection force has already put a ban on the use of a certain type of scraper system, another has openly voiced opposition to long faces, and a third has barred methods or systems that require the driving of single entries. While there are plenty of good and sufficient reasons why the newer or concentrated systems using mechanical rather than man power can, will, and should be used in our mines, there is absolutely no justification for attempting to utilize these newer ideas without the taking of common-sense precautions looking to the safety of the mine and of the miners as well as to lower costs and to increased tonnage.

Generally it is futile to discuss dangers unless there can be given some specific cases of occurrence of accidents; unfortunately, notwithstanding the newness of this type of work there is no dearth of such instances in connection with mechanical mining or with so-called concentrated systems. A recent explosion in Wales has been blamed upon methane ignition by a conveyor, and while the proof is not as definite as one would like, on the other hand the methane accumulation in this mine is very likely to have been caused by the lax methods of ventilation that only too generally accompany the newer mechanical systems. The explosion was not very violent or widespread, but it killed 51 men because of their being concentrated around the conveyor work.

In a pitching seam in the western part of the United States methane was ignited from an open electric motor on a face conveyor and 11 workers were killed; this affair also illustrates one of the inherent dangers of concentrated systems, since this gas ignition extended only a few hundred feet and produced practically no violence, and the 11 men were killed because of their being concentrated within approximately a 200-foot length of conveyor, and it is probable that the flame from this ignition would have caught only the usual one or two workers if it had occurred in the ordinary room of the older method of work. Here again was the sluggish ventilation which accompanies the new or concentrated systems so often that it seems inherent to them.

In a southern mine nine workers along a scraper face were killed on an off shift while timbering, undercutting, etc., to prepare for the oncoming shift, and in this instance the gas was probably ignited by an open light; again, there was merely a local inflammation with little or no violence, and again, lax ventilation methods were used. The large death list was, moreover, due to concentration of workers in a small area, and under the room-and-pillar system only the usual one or two room workers would probably have been caught.

In a western mine of fairly large capacity which had a record of no fatalities over a comparatively long period, a conveyor system was installed in one place, and within a year there had been three fatalities, one at a time, in the one working place served by the conveyor; here the trouble seemed to be largely a matter of too much noise by the conveyor, the workers being unable to hear the usual slight warning noises preceding the falling of rib or roof material when the older method of working was utilized. The occurrence of accidents when excessive noise at working faces drowns the noise of props or roof failing is difficult to avoid; face machinery should be kept well oiled and in good repair and should be stopped at intervals to allow surrounding conditions to be ascertained. Water used to wet the coal tends to reduce the noise from conveyors, scrapers, loaders, etc.

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In another mine in which a scraper system was handling the coal from a long face of about 300 feet, coal had been removed from a comparatively large area and the overlying material was held by props when a mass of overlying sandstone about 150 feet in length and 20 or more feet in width with a thickness of 10 or more feet fell without warning and caught two men; it developed that the mine foreman had examined the place less than one-half hour previous to the fall and found it apparently safe, there being no evidence of undue weight on the props, nor could the impending fall be detected by the usual roof-sounding methods. In this case undoubtedly too much reliance was placed upon the comparatively solid roof and upon props to hold the roof; props are far too often relied upon to hold safe the places where there is concentration of numerous workers, and in general it would be decidedly safer and in the long run cheaper and more efficient if cribs rather than props were used where numerous workers are assembled in long-face work, whether with conveyors, scrapers, loaders, or otherwise.

One of the most alarming features about the newer systems of mining is the laxity in connection with ventilation, the above-mentioned explosions at long faces being examples; and one of the worst forms of the tendency to resort to ventilation makeshifts in the newer type of work is the use of blower fans and tubing in supposedly ventilating coal-mine faces. There have been numerous disasters due to the use of these fans in coal mines, and recently four men were killed in consequence of methane ignition where an entry-driving machine working face was forced to rely upon a blower fan and tubing for ventilation; there was the usual daily methane accumulation which must be expected upon coming on shift in the morning after the blower has been shut down since the previous shift the night before, and the methane in this instance was ignited either by electricity or by open lights.

Carelessness in the use of electricity in connection with scrapers, conveyors, loaders, fans, etc., is the rule rather than the exception; comparatively recently four men, one after another, were killed while trying to move an electrically driven blower in a mine, and in another instance a worker was killed upon coming in contact with an open knife switch controlling electric current to a small blower fan. These electrical accidents are by no means infrequent; they are likely to become increasingly numerous, and their elimination is one of the real problems in connection with the newer mining systems.

Probably the most dangerous feature as concerns safety when these concentrated methods are used comes from the fact that it frequently, if not generally, is considered necessary to complete a full cycle of operations daily if the methods are to be successful; and to complete this cycle of operations each day mining men appear to be willing to cast aside one precautionary practice after another long determined as necessary to keep mines safe; in fact, it is frequently found that practices are used in the mechanized sections of a mine which would not be countenanced in the other parts of the same mine which are using older systems of working. Below are given some of the hazards noticed where the newer systems are being used:

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1. In a conveyor or electric loader system operation one usually finds open arcing types of electric motors, switches, etc., at or very close to faces which give off or are at any time likely to give off methane; wires poorly insulated or bare are poorly placed and poorly supported, and only too frequently the wires lie on the floor and workers are expected to "watch their step" when walking around.

2. Much dust is thrown into the air in connection with conveyor or loader work, the very fine (hence most dangerous) dust settling on adjacent surfaces, especially in the open region from which the coal has been removed; therefore in case of a fall of roof in that open region there are likely to be forced over the open arcing electrical equipment not only clouds of fine dust but also methane.

3. Frequently blasting is done during the working shift, and it is not at all uncommon to see 50 or more pounds of explosive with 25 or more detonators on the floor within a few feet of electric wires or motors or the open lights of workers; nor is it uncommon to see numerous blasting holes loaded ready to blast with workers using open lights and electrical equipment in operation close by.

4. When shots are fired during the working shift the workers are withdrawn only a short distance, hence in case of a blown-out shot or gas ignition from blasting the workers are likely, in fact are almost certain, to be killed or at least seriously injured. In blasting during the shift usually permissible explosives are employed, but only too frequently this good feature is partly nullified by using fuse instead of electric blasting or by shooting several holes at a time electrically (a poor practice, especially where men are in the mine). In some instances black blasting powder is used in this blasting during the shift, and this is little less than criminal, especially where the black blasting powder is tamped with coal dust and detonated by fuse or squibs.

5. In the hurry to complete the cycle of operations (upon returning after a blast) a minimum of attention is given inspection of the face region for methane or examination of roof conditions, and timbering is done before resumption of work only when absolutely necessary.

6. Under some roof conditions an appreciable length of time elapses after blasting before the roof will actually fall in pillar or long-face work, and where there is an "urge" to complete the cycle of operations little or no time is spared to await action of the roof, hence there are likely to be (and in fact there have been) accidents from falls of roof from this cause; much if not all of this hazard is escaped in ordinary room-and-pillar work, where shooting is or should be done after the working shift or at the end of the shift.

7. Generally reliance is placed upon props (frequently with very few props in position) to hold the roof (even with an extensive worked-out area) or to determine the line of break in the roof; in most cases props are entirely inadequate for this service, and in the long run are more expensive than would be an adequate system of cribs.

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8. Scrapers, mechanical loaders, and, to a smaller extent, conveyors tear out props or cribs, and only too frequently operations are kept going irrespective of dangers caused by the removal of the roof supports, leaving the props or cribs to be replaced or not, as may be determined later on by the boss or the timberman.

9. There is generally very little clearance or adequate guarding of moving or electrically-charged parts around mechanical equipment near face regions, and workers have a minimum opportunity to travel without being injured.

10. Mechanical equipment, such as electric drills, blowers, mining machines, loaders, conveyors, and scrapers, is noisy, hence while in operation at or near face regions the noise from the equipment prevents the workers from hearing the more or less slight warning sounds generally given before a roof or rib falls; this is decidedly serious, inasmuch as the newer systems, with their concentrated, more or less continuous attack keep the roof and rib almost continually moving, and the worker is practically deprived of his main warning of danger because of the noise of the machinery.

11. The advocates of nearly every so-called concentrated system give reason after reason why it is essential that single entries of various lengths are necessary, and each advocate advances reason after reason why single entries of 200 to 1,000 or more feet are safe, notwithstanding that it has been one of the axioms of safe and sane coal mining that under no circumstances should any single underground opening be driven to a length of more than 200 feet; it is true that in many instances in the past single entries longer than 200 feet have been driven, but it is equally true that many disasters have resulted from this and it is also true that several such disasters have occurred in recent years. Moreover, the driving of single entries is not necessary to the success of practically any methods new or old, notwithstanding voluminous arguments to the contrary.

12. One of the worst makeshifts to which resort is had in this single-entry driving is the use (or rather the flagrant misuse) of blower fans and tubing for ventilation, notwithstanding the fact that these units are operated only during the working shift; hence methane is almost certain to accumulate at the faces during 8 to 16 hours per day. Moreover, these units are almost invariably poorly installed, especially as to electric wiring and fireproofing, and many fires and electrocutions as well as explosions have occurred and undoubtedly will occur from these installations.

13. Under stress of completing the cycle of operations in the concentrated systems there frequently is no hesitancy to allow (in some instances practically to force) workers to work around or under missed shots or to work in close proximity to missed shots while these are being removed or otherwise handled.

14. When rock or extra-large pieces of coal are brought down by blasting or happen to fall in such manner as to impede the operation of conveyors, loaders, scrapers, etc., there is little or no hesitancy in many mines to use the quick, lazy, and decidedly dangerous "adobe" or "sand-blast" shot rather than take the necessary time to remove the impediment safely by drilling a hole and using inert

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stemming with electric blasting with the shift out of the mine. It is futile to state that permissible explosive is used in these "adobe" shots; any "adobe" shot is dangerous, and "adobe" or "sand" blasting should be prohibited in any coal mine at any time. Most certainly no "adobe" or "sand-blast" shot should be fired in any coal mine when a working shift is in the mine.

15. Economically, the weak point in most of the concentrated mining systems centers in haulage, and here again safety is sacrificed. Trolley locomotives and trolley-locomotive wires are brought almost up to dusty or gassy faces, and open-type cable-reel locomotives or open-type storage-battery locomotives are sent to similar places. In most mines the haulage system is "swamped," and on the other hand, in order to keep haulage as well as mechanical loading equipment working full time, some mining companies do not hesitate to attack the full length of a 200 or 300 foot room pillar in several places, with utter disregard of probable squeezes, bounces, roof falls, etc., and wholly without reference to anything like a uniform pillar line.

16. One of the safety advantages claimed by adherents of the newer concentrated systems is that of more intensive supervision; yet in many instances the work is placed in charge of some young electrician, mechanic, or engineer who knows little and cares less about haulage, timbering, blasting, ventilation, etc., though he is intensely interested in the electrical or mechanical details of the equipment. Frequently this new type of work is tried out in a part of a mine using the older system, and the direction of the new work is left in the hands of the usual old-time foreman who is inherently opposed to anything he has not been accustomed to doing. In both cases the new work is likely to fail, and it will be most unusual if failure is not hastened by accidents to workers, these accidents being wholly unnecessary. The greatest possible care should be exercised in selection of actual supervising officials for this new type of work at all times; and they should be able, experienced in underground mining, preferably with technical training, and most certainly in hearty sympathy with the idea of making the new system successful not only from the viewpoint of efficiency but also that of safety. In general there should be one boss of the above type for about each 25 underground workers. This matter of constant, effective supervision immediately "on the job" is one of the most essential cogs in making the new systems of mining a "go."

17. Most of the conveyor, scraper, or loader systems demand that the coal be in fairly finely divided form and that it be thrown well out from the face; to accomplish this, comparatively large charges of explosive are used, in some instances the charges of permissible explosive exceeding the permissible limit of 1 1/2 pounds per hole. These excessive charges are dangerous in that they are more likely to precipitate blown-out shots or cause explosions than would charges within the permissible limit of 1½ pounds per hole; in addition, the excessively large charges have a decidedly harmful effect upon the roof and tend to increase accidents from falls of roof.

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18. The newer systems with long faces require the drilling of numerous holes (10, 20, or more in some cases) for blasting, this being many more than in the ordinary room or entry face, with its 2 to 5 holes. Where the holes are hand drilled the workers are prone to drill as few as possible, since hand drilling of blasting holes is decidedly laborious; this automatically results in forcing the heavy loading of the comparatively few holes drilled, and this is in many cases the cause of heavy loading of holes even when it is not necessary to blast the coal into smaller sizes for subsequent handling.

19. One of the most essential features in safe operation of concentrated systems and one most difficult of attainment is to have ample illumination; under no circumstances should open lights be allowed, and ordinary types of incandescent lighting are dangerous for use at or near faces likely to be gassy or dusty. The safest lighting available is that of storage-battery lamps of the permissible type.

20. One feature of the concentrated intensive mechanized systems of coal mining that should occasion alarm is the fact that these systems generally cause practically continuous operation of electrical equipment at or very close to faces that are gassy or dusty, and this continuous use of electrical equipment at the face throughout the shift is decidedly more dangerous than the more or less intermittent use of mining machines or electric locomotives under older systems; even the latter equipment is dangerous in the older systems unless adequately safeguarded It is significant that during the past few years ignitions of gas or dust by electricity, with resultant explosions, have jumped to more than 50 per cent of our serious coal-mine explosions, while electrical ignitions constituted less than 10 per cent of the causes of the initiation of major explosions during the period 1910 to 1924.

RECOMMENDATIONS AS TO SAFE OPERATION IN CONCENTRATED OR MECHANICAL SYSTEMS OF MINING

1. Where concentrated systems of mining are used, there should be ample, competent supervision; as a minimum there should be at least one supervising official or "boss" in constant attendance for about each 25 underground workers. These immediate, "always on the job" bosses should be experienced in mining as well as have a good working knowledge of electricity, machinery, and handling men.

2. It should be known to a certainty that those in actual charge of underground operation of the concentrated systems are in full sympathy with the system, at least in so far as giving it a fair square trial is concerned.

3. Ventilation should be even more carefully planned and conducted to and past working faces than where older systems of work are used. In a coal mine, under no circumstances should single entries be driven longer than 200 feet and under no circumstances should reliance be placed on any form of intermittent ventilation, such as is almost invariably found where blowers and tubing are used.

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4. None but the safest available types of electrical equipment, wiring, and installations should be allowed when mechanical work is being done at or close to face regions; this is true even where no explosive gas has been found.

a. Wiring should be thoroughly insulated, well supported, and strung along the rib or other place, as far as feasible from probable contact with workers.

b. Bare or poorly insulated wires or open electrical switches should not be placed along or even fairly close to the roof in parts of a mine where methane may accumulate if ventilation is interrupted.

c. Only permissible electrical equipment should be used at or near faces that are or are likely to be gassy or dusty. Open types of electrical equipment, such as conveyor or hoist motors, trolley or cable-reel locomotives, drills, etc., are decidedly dangerous when used near working faces from which coal dust is given off and are much more dangerous when explosive gas also may be present.

d. Incandescent electric lights and light wires are dangerous when used at or near faces that are or are likely to be dusty or gassy. Only up-to-date permissible storage-battery lighting should be used.

e. Although open-type electric motors or switches or bare electric wires should not be allowed at or near faces that are or may become dusty or gassy, it is realized that such equipment is being and probably will continue to be so used, and it is suggested that such equipment is much more likely to be partly safe if kept fairly close to the floor rather than close to the roof, the latter being the usual practice.

5. There should be ample, safe clearance for workers around mechanical equipment used at or near faces, the clearance being such that workers are not required to pass over or under moving or electrically charged equipment with the possibility or probability of being injured when so doing. Moving belts, gears, etc., on equipment used at or near face regions should be safely protected by adequate guards.

6. The noise made by machinery makes it difficult, if not impossible, to hear the usual warning sound given by overhanging roof or rib material before it falls. Every feasible means should be taken to reduce noise where mechanical equipment is used at or around face regions; in connection with certain types of mechanical equipment such as conveyors, the use of water not only tends to reduce noise but also aids materially in reduction of dust in and around the equipment and in the general surrounding atmosphere.

7. In general, it is much safer and even less expensive to protect concentrations of workers in the newer systems by use of cribs (which may or may not be removable) rather than to depand upon props. Props should be used as an auxiliary to the cribs or as to supplement the cribs.

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8. When timber at or around mechanized faces is torn out by machinery or by blasting, there should be no delay in its replacement, even when such action may cause temporary interruption of the usual coal-producing work.

9. After blasting there should be no hesitancy in taking sufficient time to place timber before allowing the loaders to start operations. Many accidents occur through overeagerness to start loading as soon as possible after blasting, practically irrespective of roof conditions.

10. Where at all feasible no blasting should be done when the working shift is in the mine, and all blasting in coal mines should be done by competent shot firers using only permissible explosives shot electrically, with not over 1½ pounds of explosive per hole and with holes well tamped with incombustible matter (in other words coal-dust should not be used for stemming). By far the safest method of coal-mine blasting is that where all explosive is held out of the mine during the working shift and all holes are loaded by shot firers after the shift and are fired electrically from the surface with all persons, including the shot firers, out of the mine.

11. While the above methods of blasting are absolutely practicable in addition to being safe, it is recognized that many concentrated mechanized systems are dependent upon being able to blast at any time; hence the following recommendations are given as to blasting practice when the working shift is in the mine, with the intent to safeguard as much as possible a practice known to be inherently unsafe:-

a. All holes should be loaded and fired by shot firers.
b. Only permissible explosive should be used in a coal mine, whether to bring down coal or to shoot rock. Certainly no black blasting powder or dynamite should be used in any coal mine while any men are in the mine. No hole should be charged with more than 1½ pounds of permissible explosive, whether the men are in or out of the mine, and a sufficient number of holes should be provided to allow using less than 1½ pounds of explosive per hole.
c. Blasting should be done by permissible single-shot electric blasting units.
d. All holes should be tamped with inert stemming.
e. There should be no solid shooting of coal or "adobe" blasting of coal or rock.
f. Holes should not be loaded and tamped while workers other than the shot firers are closer than 25 feet.
g. Under no circumstances should holes be loaded while electrical equipment, such as electric drills or electric coal-cutting machines, is working within 25 feet.
h. Preferably the face region should be well wet down before blasting.

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i. Workers should be withdrawn at least 500 feet before blasting, and ample warning given haulage and other adjacent workers; and loaders and other face workers should not be allowed to return after the blast until the face which has been blasted has been given a careful examination by a competent fire boss for explosive gas as well as for roof conditions or possible missed shots. It is important that ample time be given the above inspection to make it a thorough one; otherwise, there are certain to be numerous disasters in the concentrated working of coal mines. Likewise ample time should be taken to remove any dangerous condition before workers are permitted to resume loading and like operations.

j. Where shots fail to detonate, loaders and similar workers should not be allowed within 50 feet of them until these shots have been fired or the charge has been removed from the hole.

k. It is recommended that if the CO_2 method of blasting now in use in a few Indiana and Illinois mines proves safe and efficient this method or one similar to it be substituted for the usual types of explosives where it is considered necessary to blast while the working shift is in the mine.

12. With the concentration of workers and of tonnage effected by the newer systems there should be ample opportunity for better rather than the poorer ventilation usually found at the places of concentrated work, as compared with the greater scattering of workers and working places under the older systems.

a. As heretofore stated, single entries longer than 200 feet should not be allowed under any circumstances. They are difficult to ventilate, and in case of a fall men are likely to be trapped.

b. Blower fans and tubing should not be allowed in any coal mine; however, it is recognized that they are being used and probably will continue to be used, and the following requirements should be kept rigidly in effect if this equipment is to be kept in even reasonable safety.

1. They should be kept in operation 24 hours per day.
2. The region surrounding a fan should be securely fireproofed, particularly if the fan is electrically driven.
3. Electric wiring around the fan should be well insulated and well supported.
4. Electric switches at or around the fan should be of enclosed type.
5. Preferably the fan should be operated by compressed air.

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6. The fan should be located in strictly intake air and under no circumstances nearer than 300 feet to a face likely to give off methane.
7. The tubing should be fireproof or at least fire resistant, and it should be adequately supported from the roof and under no circumstances lie along the floor.

c. Workers should be withdrawn from any place or face where electrically driven machines are in use when the methane content is over 1½ per cent.
d. When a fall cuts air circulation from any working face using concentrated mining no workers should be allowed in the region (other than a limited number to restore air circulation) until ordinary ventilation has been restored. This seems an unnecessary recommendation; yet cases occur where the desire to complete the cycle of operations leads to the forcing of work even when conditions are known to be dangerous.

13. No nonpermissible electric locomotives should be allowed close to any face which gives off or is likely to give off methane; this includes cable-reel and nonpermissible storage-battery locomotives.

14. Under no circumstances should trolley locomotives be used in return air or within 300 feet of any face that gives off or is likely to give off methane or within 100 feet of any place where explosives are being used to charge drill holes.

CONCLUSIONS

There is every reason for belief that mechanized concentrated methods of mining present numerous advantages and that they will spread fairly rapidly through the coal-producing industry of the United States. There is no question that these methods are now in many instances being used unsafely and unwisely, and there is also no good reason why they can not be made safe. On the contrary, most of them can and should be made safe, and the sooner the unsafe methods and practices are discarded the fewer disasters there will be.

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